PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G01N 21/88

A1

(11) International Publication Number: WO 91/14935

(43) International Publicati n Date: 3 October 1991 (03.10.91)

(21) International Application Number: PCT/DK91/00086

(22) International Filing Date: 20 March 1991 (20.03.91)

(30) Priority data:
743/90 22 March 1990 (22.03.90) DK

(71) Applicant *(for all designated States except US)*: ABK BYGGE- OG MILJØTEKNIK A/S [DK/DK]; Birkehavevej 3, DK-3460 Birkerød (DK).

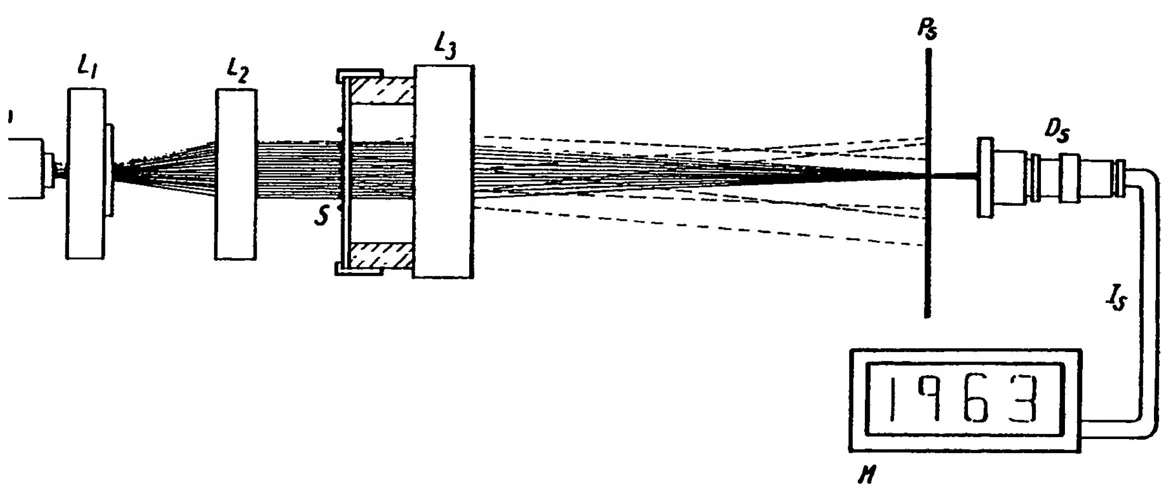
(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : PETERSEN, Ole, Holm [DK/DK]; Pårupvej 2, DK-2770 Kastrup (DK).

(74) Agents: SIMONSEN, Christian, Rosendal et al.; Internationalt Patent-Bureau, 23 Høje Taastrup Boulevard, DK-2630 Taastrup (DK).

(81) Designated States: AT (European patent), BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), NO, SE (European patent), US.

Published
With international search report.
In English translation (filed in Danish).

(54) Title: A METHOD AND AN APPARATUS FOR CLEANING CONTROL



(57) Abstract

A method and an apparatus for cleaning control by measuring the degree of dirt on a surface by means of a dust collecting adhesive foil by optically measuring an area of the adhesive foil exposed to dust and by comparing the obtained measuring value to a reference value. The optical measuring is ffected by means of a laser beam source with associated optical members for generating a beam of substantially parallel laser rays that are made to pass substantially perpendicular through the adhesive foil and

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MN	Mongolia
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Faso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	GN	Guinea	NL	Netherlands
BJ	Benin	GR	Greece	NO	Norway
BR	Brazil	HU	Hungary	PL	Poland
CA	Canada	IT	Italy	RO	Romania
CF	Central African Republic	JP	Japan	SD	Sudan
CG	Congo	KP	Democratic People's Republic of Korea	SE	Sweden
CH	Switzerland			SN	Senegal
CI	Côte d'Ivoire	KR	Republic of Korea	SU	Soviet Union
CM	Cameroon	LI	Liechtenstein	TD	Chad
CS	Czechoslovakia	LK	Sri Lanka	TG	Togo
DE	Germany	LU	Luxembourg	US	United States of America
DK	Denmark	MC	Monaco		

A method and an apparatus for cleaning control.

The invention relates to a method of cleaning control by measuring the degree of dirt on a surface by means of a dust collecting adhesive foil, in which an optical measuring is effected of an area of adhesive foil exposed to dust and a comparison of the obtained measuring value with a reference value, and a mesuring apparatus for carrying out the method.

Methods and measuring apparatuses of this type are known in which the optical measuring is generally based on measuring light transmitted by diffusion and in which an analysis of the size and quantity of particles on the adhesive tape is performed, frequently by means of advanced image data analyzing equipments. Such types of a measuring apparatus are, however, expensive and typically stationary so that a measuring of the cleanliness degree cannot be effected on the spot where the adhesive foil is being exposed.

The method according to the invention is characterized in that the area of the adhesive foil exposed to dust is placed substantially perpendicular to the radiation axis of a laser beam emitted from a laser beam source which laser beam after passage through the adhesive foil is focused on an intensity measuring photodetector, the output signal of which is fed to a measuring instrument the display of which is compared to the reference value.

A substantial simplification of the measuring is thus obtained without noticeable decline in accuracy and reproduceability of the measurings.

The measuring apparatus according to th invention is characterized by comprising a laser beam source with associated optical members for the generation of a beam of substantially parallel laser rays, a holder designed to arrange an adhesive f il dust probe and

means for positioning said holder in said parallel beams with the adhesive foil substantially perpendicular to the axis of radiation and means for focusing the beam passing through the adhesive foil holder on an intensity measuring photodetector and a measuring instrument for measuring the output signal of the detector and comparing it to a reference value.

It has thus been made possible to manufacture the measuring apparatus in an inexpensive, simply operating, portable design, thereby allowing the cleaning control to be effected quickly and on site.

Instead of performing a thorough analysis of the quantity and size of the dust particles on the adhesive tape the simplification is obtained by merely measuring the quantity of directly transmitted (laser) light, i.e. light that is neither absorbed nor scattered by the dust particles on the adhesive tape.

The invention and the preferred embodiments thereof will now be explained in detail with reference to the drawings, in which

Fig. 1 illustrates a dust-absorbing adhesive tape,

Fig. 2 is a side elevation of the adhesive tape,

Fig. 3 is a sketch of a measuring apparatus according to the invention, and

Fig. 4 illustrates a holder, disposed on a vacuum cleaner pipe, for the exposure of the adhesive foil by measuring the dirt degree of a shaggy surface.

Prior to use the adhesive foil illustrated in Figs 1 and 2 is provided on its adhesive surface with a cover sh et, not shown. Immediately before the exposure of th adhesive foil the cover sheet is remov d and a reference m asurement of the un xpos d adhesive tape is either effected at onc , or part of the adhesive tape is maintained unexposed (see Figs 1 and 2) for effecting the reference measurement later on.

Th exposure on a smooth surface is obtained by pressing the adhesive foil against the surface, the adhesive side facing downwards; on a shaggy surface by arranging the adhesive foil in a holder, illustrated in Fig. 4, inserted in a vacuum cleaner pipe, and subsequent vacuum cleaning of the shaggy surface for a predetermined period. In order to obtain a uniform distribution of the dust particles across the adhesive foil, said holder may have a turbulence forming, conical contraction as illustrated in Fig. 4.

After exposure, the adhesive tape is placed in measuring position within the measuring apparatus in Fig. 3, in which laser beams from a laser diode LD by means of lenses L_1 and L_2 are made to impinge on the adhesive foil in a parallel beam at the measuring position S. Part of the incident laser light will then be scattered and part of the light will be absorbed by the dust particles on the adhesive foil, while the remainder by means of a lens L_3 with relatively large focal length (f) will be focused, preferably through a pinhole diaphragm P_S, on a detector D_S, for measuring the transmitted intensity whose output signal is fed to the measuring instrument M for displaying a measuring figure.

When an area A(o) of the adhesive foil surface is exposed to dust is hit by light with an intensity I(o), part of the light will be removed by absorption in the dust particles and another part will be removed by scattering. The quantity of light I(removed) which the dust removes is determined by the effective area of the dust A(eff), i.e.

$$\frac{I(\text{removed})}{I(o)} = \frac{A(\text{eff})}{A(o)} = \frac{E \cdot A}{A(o)}$$

wherein E is the extinction coefficient and A is the ar a of the projection of dust perpendicular to the light beam. E depends on the ratio between the par-

ticle size and th wavelength of the light and is close to 2 when this ratio is large (Broomhead et al, 1960). In practice E is an average value determined by the optical properties and the actual size of the particles.

By measuring transmitted light intensities with and without dust on the adhesive tape (I(dust), I(ref)) the result is:

$$\frac{I(\text{removed})}{I(o)} = 1 - \frac{I(\text{dust})}{I(\text{ref})} = 1 - \frac{\text{measuring figure(dust)}}{\text{measuring figure(ref)}},$$

wherein I(dust) is the current signal from the detector measured by the measuring instrument M in connection with an adhesive foil exposed to dust and I(ref) is the measured current signal from the detector in connection with an unexposed adhesive foil (reference).

The purpose of the pinhole diaphragm is to prevent scattered light from becomning a part of the measured transmitted light intensity. It applies to the illustration in Fig. 3 that the angle θ from the main beam, within which scattered light is detected, is determined by $\theta \approx \text{tg}\ \theta = \text{Ø (pinhole)}/2\cdot f$ [rad], wherein f is the focal length for the lens L_3 and thus also the distance between lens L_3 and the pinhole diaphragm P_s (f = 150 mm).

Scattered light within 3° from the main beam is by and large merely due to diffraction. As regards particle sizes less than about 20 µm (in diameter), less than 2% of the totally scattered, reflected and absorbed light will fall within 0.14° from the main beam corresponding to a pinhole diameter of 1 mm for f = 150 mm (J.R. Hodkinson and Greenleaves 1963). Due to the detection of scattered light no more than 2% too high intensity of transmitted light will consequently be measured, by this masuring set-up.

In view of the fact that the light scattering angle depends on the particle size there may, by using

a stepwise variable pinhole diaphragm, e.g. Ø(pinhole) = 0.2 mm, 0.3 mm, 0.6 mm, 1.0 mm, 2.0 mm and 3.0 mm, corresponding to detection angles of 0,024°, 0,036°, 0,072°, 0,12°, 0,24° and 0,36°, respectively, be obtained numeric values giving a rough description of the particle size distribution.

In the illustrated example of the measuring apparatus according to the invention the radiation source is preferably a laser diode and the photodetector a photodiode and the apparatus has been made portable by accommodating a battery for power supply to the measuring circuitry.

PATENT CLAIMS

1. A method of cleaning control by measuring the degree of dirt on a surface by means of a dust collecting adhesive foil, in which an optical measuring is effected of an area of the adhesive foil exposed to dust and a comparison of the obtained measuring value with a reference value, characterized in that the area of the adhesive tape foil exposed to dust is placed substantially perpendicular to the radiation axis of a laser beam emitted from a laser beam source which laser beam after passage through the adhesive foil is focused on an intensity measuring photodetector, the output signal of which is fed to a measuring instrument the display of which is compared to the reference value.

2. A method as claimed in claim 1, characterized in that the reference value is obtained by measuring an area of said adhesive foil that is not exposed to dust.

3. A method as claimed in claim 2, characterized by using for the sampling an adhesive foil item of which only part is exposed to dust, following which in the same measuring operation a measuring is effected on the part exposed to dust as well as on the part not exposed to dust of the adhesive foil item serving to produce the reference value.

4. A method as claimed in claim 2, characterized in that prior to sampling the dust the reference value is calibrated by effecting the measuring on the part of the adhesive foil which is successively used for sampling the dust.

5. A method as claimed in any of the preceding claims for measuring the dirt degree of a smooth surface, characterized by taking a dust sample from the surface by means of an adhesive foil item.

6. A method as claimed in any of claims 1 to 5, for measuring the dirt degree of a shaggy surface, characterized in that a dust sample is taken from the

surface by disposing an adhesive foil item in a holder that is inserted in a vacuum cleaner pipe, and vacuum cleaning for a predetermined time, thereby causing part of the absorbed dust to settle on the adhesive foil.

7. A method as claimed in claim 4, characterized by imparting turbulence to the air in the area of said holder for the adhesive foil, by means of a conical contraction, thereby causing the dust to be uniformly distributed across the adhesive foil.

8. A method as claimed in any of the preceding claims, characterized in that the laser beam is focused on the photodetector by means of a lens with comparatively large focal length and through a pinhole diaphragm having an aperture such that the detection angle of radiation is less than 0.12°.

9. A measuring apparatus for carrying out the method as claimed in any of the preceding claims, characterized by comprising a laser beam source with associated optical members for generating a beam of substantially parallel laser rays, a holder designed to arrange an adhesive foil dust probe and means for positioning said holder in said parallel beam with the adhesive foil substantially perpendicular to the axis of radiation and means for focusing the beam passing through the adhesive foil tape holder on an intensity measuring photodetector and a measuring instrument for measuring the output signal from the detector and comparing it to a reference value.

10. A measuring apparatus as claimed in claim 9, characterized in that the light source is a laser diode and the photodetector is a photodiode.

11. A measuring apparatus as claimed in claim 10, characterized in that a pinhole diaphragm is arranged in front of the photodiode and a lens with comparatively large focal length is arranged behind the adhesive foil holder.

12. A measuring apparatus as claimed in claim 11, characterized in that the aperture of the pinhole diaphragm is stepwise variable to obtain radiation detection angles of e.g. 0,024°, 0,036°, 0,072°, 0,12°, 0,24° and 0,36°.

13. A measuring apparatus as claimed in claim 11, characterized in that the aperture of the pinhole diaphragm is chosen so that the radiation detection angle is less than 0.12°.

14. A measuring apparatus as claimed in claims 9, 10, 11, 12 or 13, characterized by being portable.

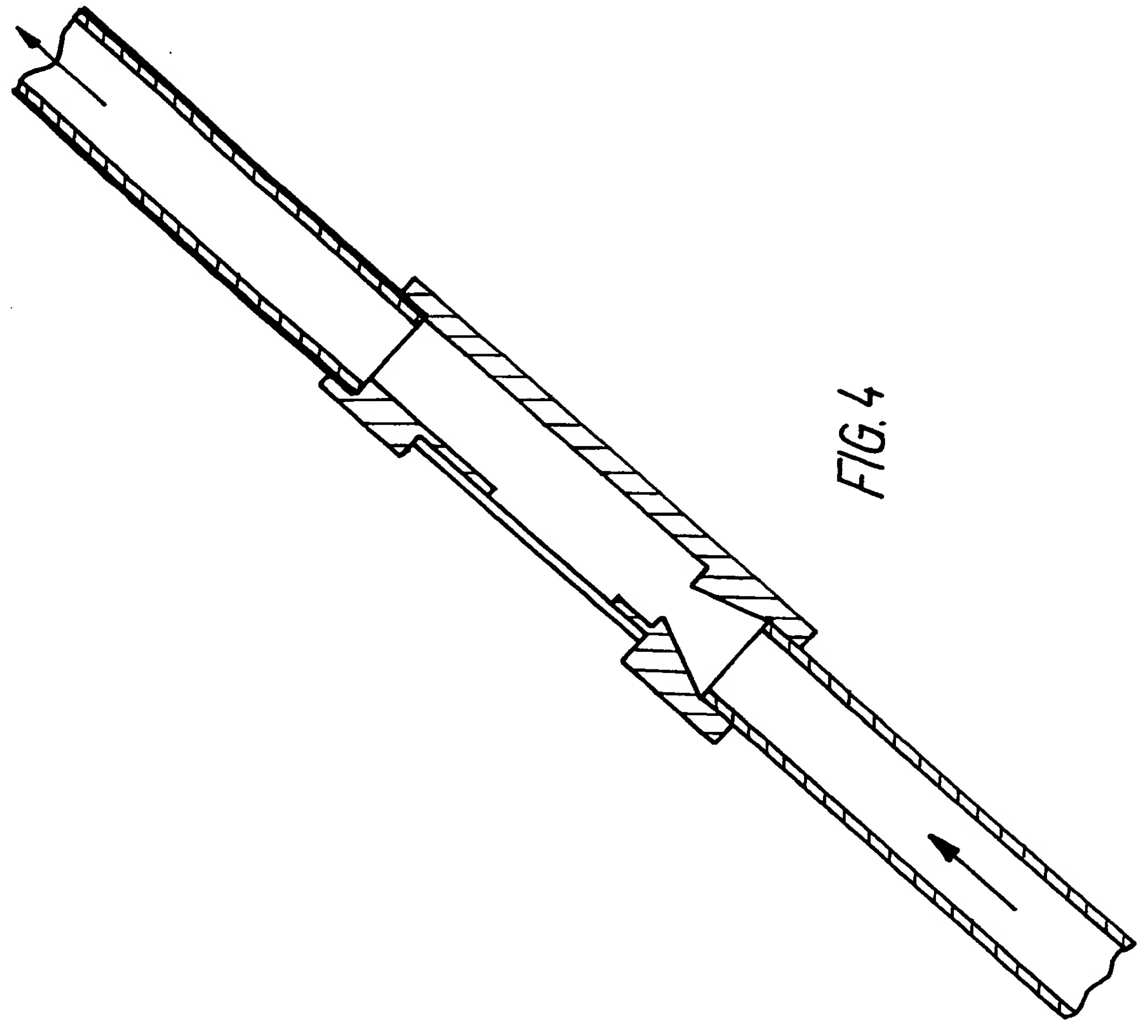


FIG. 4

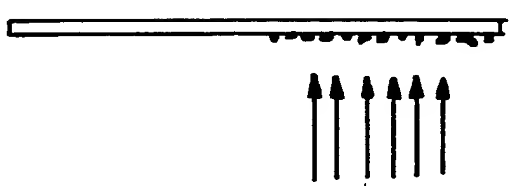


FIG. 2

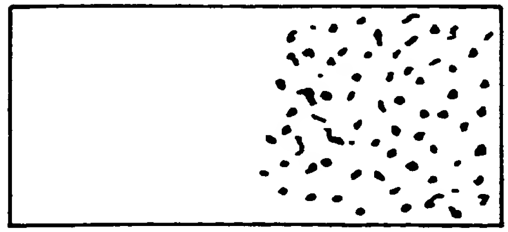


FIG. 1

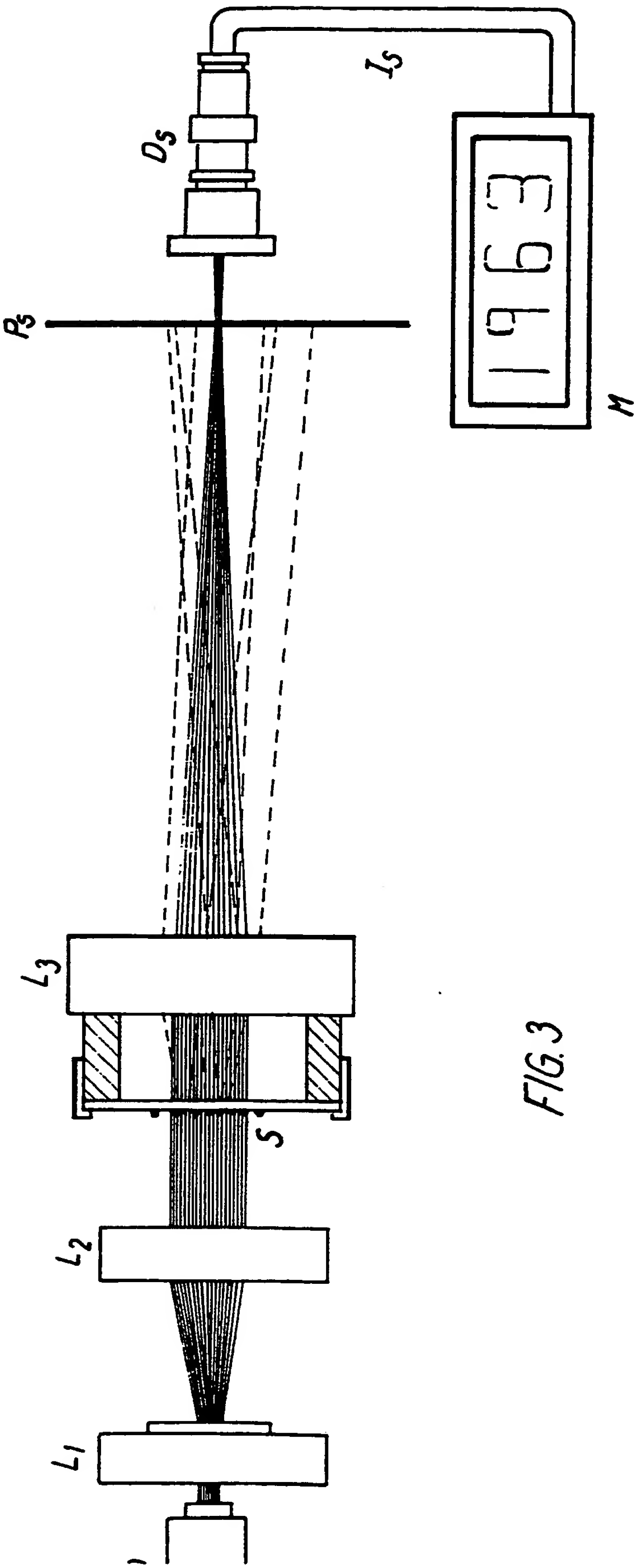


FIG. 3

INTERNATIONAL SEARCH REPORT

International Application No PCT/DK 91/00086

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: G 01 N 21/88

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	G 01 N

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	GB, A, 2119506 (CANON KABUSHIKI KAISHA) 16 November 1983, see abstract; figure 4 --	1-14
A	WO, A1, 8707024 (HUGHES AIRCRAFT COMPANY) 19 November 1987, see abstract; figure 1 --	1-14
A	US, A, 4598997 (STEIGMEIER ET AL) 8 July 1986, see abstract --	1-14
A	US, A, 4767213 (K. HUMMEL) 30 August 1988, see abstract --	1-14

* Special categories of cited documents:[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
13th June 1991	1991 -06- 27
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	KARIN SÄFSTEN

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	DE, A1, 3626724 (SIEMENS AG) 11 February 1988, see column 2, line 44 - column 3, line 16; figure 1 --	1-14
A	US, A, 4402607 (MCVAY ET AL) 6 September 1983, see abstract --	1-14
A	Patent Abstracts of Japan, Vol 12, No 51, P667, abstract of JP 62-197751, publ 1987-09-01 TOSHIBA CORP. --	1-14
A	Patent Abstracts of Japan, Vol 11, No 203, P591, abstract of JP 62- 25244, publ 1987-02-03 HITACHI LTD --	1-14

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/DK 91/00086

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the Swedish Patent Office EDP file on 91-05-29
The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 2119506	83-11-16	DE-A- 3310341	83-09-29
		FR-A-B- 2524162	83-09-30
		JP-A- 58162038	83-09-26
		US-A- 4669885	87-06-02
WO-A1- 8707024	87-11-19	EP-A- 0264427	88-04-27
		JP-T- 63503243	88-11-24
US-A- 4598997	86-07-08	NONE	
US-A- 4767213	88-08-30	EP-A- 0231419	87-08-12
		JP-A- 62217932	87-09-25
DE-A1- 3626724	88-02-11	NONE	
US-A- 4402607	83-09-06	DE-A-C- 3048053	82-01-07
		FR-A-B- 2482719	81-11-20
		GB-A-B- 2076962	81-12-09
		JP-B- 1043901	89-09-25
		JP-C- 1562430	90-06-12
		JP-A- 57008435	82-01-16